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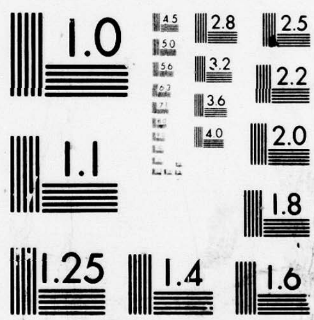

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Research Report 1217

LEVEL II

EFFECTS OF FATIGUE FROM WEARING THE AN/PVS-5 NIGHT VISION GOGGLES ON SKILLS INVOLVED IN HELICOPTER OPERATIONS

Garvin D. Chastain and Albert L. Kubala
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ARI FIELD UNIT AT FORT HOOD, TEXAS

U. S. Army
Research Institute for the Behavioral and Social Sciences

July 1979

U. S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

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Reviews of the literature on rotary wing flight and interviews with aviators were conducted to determine which helicopter tasks and maneuvers are performed most frequently and/or are the most critical. Those operations found to be most critical were analyzed into perceptual and psychomotor components, and a battery of perceptual and psychomotor tests was selected to measure these factors. Aviators were tested both before and after flying with the AN/PVS-5 goggles. Eye-hand coordination was marginally affected following flight, and reaction time to lights was significantly affected.

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FOREWORD

The Fort Hood Field Unit of the Army Research Institute for the Behavioral and Social Sciences (ARI) provides support to Headquarters, TCATA (TRADOC Combined Arms Test Activity). This support is provided by assessing human performance aspects in field evaluations of man/weapons systems.

A war using modern weapons systems is likely to be both intense and short. US man/weapons systems must be effective enough, immediately, to offset greater numbers of an enemy. Cost-effective procurement of improved or new combat systems requires testing that includes evaluation of the systems in operational settings similar to those in which the systems are intended to be used, with troops representative of those who would be using the systems in combat. The doctrine, tactics, and training packages associated with the systems being evaluated must themselves also be tested and refined as necessary.

This report presents the results of a study designed to evaluate the effects on critical helicopter operations of fatigue induced by wearing the AN/PVS-5 Night Vision Goggles. The study specifically determined the piloting tasks most crucial and/or frequently performed, the skills involved in performing those tasks, and the effects of flying with the goggles on those skills.

ARI research in this area is conducted as an in-house effort, and as joint efforts with organizations possessing unique capabilities for human factors research. The research described in this report was done by personnel of the Human Resources Research Organization (HumRRO), under contract MDA907-78-C-2017, monitored by personnel from the ARI Fort Hood Field Unit. This research is responsive to the special requirements of TCATA and the objectives of RDTE Project 2Q763743A775, "Human Performance in Field Assessment," FY 1978 Work Program.

Joseph Zeidner

JOSEPH ZEIDNER
Technical Director

EFFECTS OF FATIGUE FROM WEARING THE AN/PVS-5 NIGHT VISION GOGGLES ON SKILLS INVOLVED IN HELICOPTER OPERATIONS

BRIEF

Requirement:

The work carried out in this study is that referred to in paragraph 4.b.4 of the Statement of Work dated 18 July 1978 under the title "Study of Fatigue with the AN/PVS-5 Night Vision Goggles." The following objectives guided the study:

- To determine which helicopter tasks and maneuvers are the most crucial and/or frequently performed.
- To ascertain the specific visual and motor skills involved in performing the critical tasks.
- To determine which of the critical skills are significantly degraded from AN/PVS-5 Night Vision Goggle (NVG) wear, and by inference, performance of which of the critical tasks would be expected to suffer.

Procedure:

Review of the literature on rotary wing flight and interviews of aviators conducted locally were undertaken to determine which helicopter tasks and maneuvers are performed most frequently and/or are most crucial.

Those operations found to be critical were analyzed, and the extent of involvement of particular skill factors most readily tested with perceptual and psychomotor apparatus tests was determined. Tests requiring the skills most heavily involved in the critical operations were selected.

The selected tests were administered to 10 aviators before and after flights in which the NVG were worn.

Principal Findings:

- Eye-hand coordination, rapid reaction to visual cues, and coordination of the limbs were involved in almost all critical helicopter operations.
- Reaction to visual cues was significantly degraded after NVG flights, and eye-hand coordination exhibited a marginally significant decrement.

Utilization of Findings:

The results described in this report indicate that fatigue resulting from NVG wear affects performance on tasks directly involved in helicopter operation. After lengthy NVG wear a general degradation in piloting ability would be expected. Efforts to limit the length of continuous use of the NVG seem prudent. The current findings should be useful in planning research designed to develop ways to reduce fatigue from NVG wear or to minimize the adverse effects of such fatigue.

CONTENTS

TABLES (cont'd)

FIGURE

Chapter 1

INTRODUCTION

The AN/PVS-5 Night Vision Goggles (NVG) have been shown to substantially facilitate helicopter operation under nighttime luminance conditions.[1] With the aid of the NVG, such tasks as Nap-of-the-Earth (NOE) flying can be performed at night in the absence of light sources which would invite detection and location by enemy forces.

Aviator complaints of fatigue resulting from extended wear of the NVG led to a recent series of investigations of the problem.[2] Objectives of the investigations were to determine systematically the types of performance abilities which suffer as a result of NVG-related discomfort and fatigue and the frequency of such problems. Problems with fatigue were found to be widely experienced. Common physical symptoms resulting from lengthy goggle wear were identified as presure on the nose and cheek bones, fatigue of neck muscles, eyestrain, and headaches. Results of a series of visual and psychomotor tests administered to aviators before and after flights involving extended NVG wear indicated that eye-hand coordination (as measured by the Pursuit Rotor Test) and visual efficiency (as measured by the Critical Flicker Fusion Test) are affected after one to four hours of NVG use.

In light of the performance changes that were observed, a determination of the effects of fatigue induced by NVG wear on the particular skills involved in helicopter operation becomes desirable. Accordingly, the current investigation was directed toward examining the role of specific visual and motor skills in helicopter operation, and the effects of fatigue from NVG wear on these skills.

The first phase of the research involved a determination of which helicopter tasks and maneuvers are the most crucial and/or frequently performed. The determination was made from information gathered from both the literature on rotary wing flight and interviews of aviators conducted locally. Those operations so indicated were analyzed to ascertain the specific visual and motor skills involved in their performance. The skills found common to a number of tasks were identified.

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[1] G. B. Stevenson. *Combat Air Vehicle Navigation and Vision (CAV NAV)*, LWL Technical Report No. 74-36, US Army Land Warfare Laboratory, Aberdeen Proving Ground, Maryland, December 1973.

[2] G. D. Chastain, W. H. Ton., and A. L. Kubala. *Fatigue Effects From Wearing the AN/PVS-5 Night Vision Goggles*, ARI Technical Report, Human Resources Research Organization, Alexandria, Virginia, in process.

During the second phase, descriptions of various perceptual and psychomotor apparatus tests were reviewed to determine the extent to which each of the skills identified is involved. Studies evaluating the apparatus tests to identify those which predict successful pilot performance were reviewed. The feasibility of administering each test under the prevailing local conditions was determined. From those considered feasible, several tests which seem to reflect the proficiency level of the relevant skills were selected for use.

Finally, aviators who were unfatigued (preflight) and fatigued (after a flight involving NVG wear) were given the selected tests. The effect of fatigue from NVG wear on each skill was inferred from differences in test results between the preflight and postflight conditions. Those helicopter operations were identified which required the skills most adversely affected.

Chapter 2

TASK ANALYSIS AND TEST SELECTION

Both literature reviews and interviews with Army personnel were conducted to determine those tasks central to helicopter operations. Performance factors reflected in those psychomotor apparatus tests historically used in pilot selection were each analyzed for frequency of involvement in those tasks. Tests evaluating the factors most frequently involved were chosen to be administered in a fatigue evaluation study.

Literature Review

A review of relevant Army documents was conducted as a first step in identifying the most crucial and/or frequently performed helicopter tasks and maneuvers. Training Circular (TC) 1-37[1] outlines the maneuvers/procedures and standards used for qualification or evaluation flights. Of particular relevance for current purposes is the list of tasks and descriptions in Chapter 4 of the circular. Each mandatory flight evaluation maneuver is indicated with an asterisk (*), and those maneuvers so indicated were selected as critical items for current purposes. Before-flight checks were excluded, as were Inadvertant Meterological Coordination (IMC) procedures, since instrument flying is less frequent with the NVG. A list of the critical tasks and a description of each appears in Table 2-1.

Personnel Interviews

Interviews were conducted with Instructor Pilots (IPs) from the Sixth US Cavalry Brigade (Air Combat) [6th ACCB] to identify operations critical in NVG flying other than those listed in Table 2-1. The IPs reported five additional items covered locally on an NVG checkride (necessary for trainees to qualify for flying with the NVG outside the presence of an IP) which appear as non-mandatory flight evaluation maneuvers in TC 1-37. These additional items are listed and described in Table 2-2.

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[1] US Department of the Army. Training Circular 1-37, "Qualification Training and Standardization, OH-58," Washington, D.C., 30 September 1977.

Table 2-1. Critical Tasks Listed in TC 1-37

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1. *Task:* Perform a normal takeoff from the ground and/or a hover.

   Description:

   From the Ground: Place cyclic in neutral position. Increase collective, maintaining heading with pedals. As the aircraft leaves the ground, apply cyclic as necessary to accelerate forward at the minimum altitude commensurate with terrain obstacles. As effective translational lift is reached and the ascent begins, apply forward cyclic to attain a 60-KIAS attitude. Adjust power as required to establish the desired rate of climb. Above 50 feet AGL, place aircraft in trim.

   From a Hover: Apply forward cyclic to accelerate to effective translational lift; maintain heading with pedals. Maintain altitude with collective. As effective translational lift is reached and as the ascent begins, apply forward cyclic to attain a 60-KIAS attitude. Adjust power to establish the desired rate of climb. Above 50 feet, place the aircraft in trim.

2. *Task:* Perform a normal approach to a hover and/or to the ground.

   Description:

   To a Hover: When the approach angle is intercepted, decrease collective to establish the descent. Maintain entry airspeed until the apparent ground speed and rate of closure seem to be increasing. Progressively decrease the rate of descent and forward speed until a 3-foot hover is established over the intended landing spot.

   To the Ground: Proceed as in "approach to a hover," except that the descent is continued to the ground. Make touchdown with zero groundspeed. After ground contact, fully lower the collective; neutralize pedals and cyclic.

3. *Task:* Perform a simulated maximum performance takeoff.

   Description: Place cyclic and pedals in neutral position. Slowly decrease collective. As helicopter leaves the ground, increase collective to 5 psi above hover power. Insure helicopter leaves the ground in a 40-KIAS attitude. Maintain takeoff heading with cyclic and pedals. At 100 feet AGL, place aircraft in trim, increase airspeed to 60 KIAS, and adjust power to establish the desired rate of climb.

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4. *Task:* Perform hover out-of-ground effect.

Description: Perform before-takeoff and power checks. Clear aircraft. Vertically ascend to approximately 25 feet, constantly monitoring turbine outlet temperature (TOT), torque, and aircraft instruments in order not to exceed aircraft limitations. Make a 360-degree pedal turn.

5. *Task:* Perform masking and unmasking.

Description:

Mask. With aid of a map, fly to the objective, taking maximum advantage of existing terrain and vegetation. To insure a masked condition, use all available concealment to avoid detection.

Unmask.

- In Flight. To unmask from a masked condition, minimal exposure time should be maintained to avoid enemy detection and confirm map interpolation.

- Hover. When unmasking, no forward movement should be made. Horizontal main rotor blade clearance should be maintained with the obstacles in case of loss of power or the tactical need to mask the aircraft quickly. Move to another location before unmasking again.

6. *Task:* Perform a standard autorotation with turn.

Description: Maintain entry altitude as directed and entry airspeed of 80 KIAS until the entry point is reached. Initiate the maneuver by reducing the collective to the full down position, retard the throttle to the engine-idle stop, and use pedals to maintain trim. Adjust cyclic to produce a 60-KIAS attitude and start a coordinated turn. During the descent, the rate of turn may be adjusted as necessary to assist in reaching the intended touchdown point. An application of collective may be necessary to maintain rotor RPM within limits (330 to 390 RPM). Check the rotor RPM and gas-producer and call out, e.g., "Rtor RPM in the green, gas-producer, 62 percent." Upon reaching 220 feet AGL, the aircraft must be in a 60-KIAS attitude and rotor RPM within limits. The helicopter must have a normal rate of descent, be aligned with landing heading, and in position to terminate in the intended touchdown area. At approximately 50 feet AGL and a minimum of 60 KIAS, apply aft cyclic, as necessary, to initiate a smooth deceleration. As airspeed decreases, additional rearward cyclic pressure may be required to gain maximum deceleration effectiveness. Insure

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alignment of the aircraft with the runway by proper application of pedals and cyclic. Position collective, as required, to prevent rotor RPM from increasing above 390 RPM. At approximately 10 feet skid height AGL, apply sufficient collective to minimize the rate of descent and groundspeed. The amount of collective applied and the rate at which it is applied will depend upon the rate of descent. Use collective as necessary just prior to touchdown to cushion the landing.

7. *Task:* Perform a low-level autorotation.

Description: During the turn to base, initiate a descent to as to arrive on final at 50 feet AHO. Minimum altitude on base is 300 feet AGL. From an entry altitude of 50 feet AHO at 80 KIAS with cruise power and at a point which assures touchdown in the first third of the intended landing area, simultaneously retard the throttle to the engine-idle stop, lower the collective to the full down position, trim the aircraft with pedals, and apply aft cyclic to maintain entry altitude. As the aircraft begins to descend, continue as in the termination of a standard autorotation.

8. *Task:* Perform a simulated hydraulic system malfunction.

Description: Perform before-landing check. Insure the student is familiar with the cyclic hardover characteristics. Place hydraulic control switch in the OFF position using the following procedure:

The Instructor Pilot (IP) will identify the hydraulic control switch by placing his hand on the hydraulic control switch and verbally verified that it is the hydraulics switch.

The pilot at the controls will verify that the instructor has, in fact, placed his hand on the hydraulic control switch and verbally verified that it is the hydraulics switch.

The IP will then turn off the hydraulic control switch while guarding the cyclic with the other hand in the event of a hydraulic malfunction.

After the pilot verifies normal function of controls, the IP may remove the hands from the controls and reset the master caution light. Maintain desired heading and altitude while simulating the performance of the emergency procedural action described in TM 55-1520-228-10. The checklist will be used to verify that proper procedures are followed. When a shallow approach angle is intercepted, decrease collective as required to establish and maintain that angle. Maintain airspeed until such time as apparent

ground speed and rate of closure seem to be increasing. Then progressively decrease rate of descent and forward speed to facilitate a touchdown of 0 to 5 knots groundspeed within the first usable one-third of the lane. Just prior to touchdown, apply sufficient collective to effect a smooth touchdown. After touchdown, maintain lane alignment with cyclic, heading with pedals, and slowly decrease collective to minimize forward speed.

NOTE: Should the aircraft tend to turn or drift during the ground slide after touchdown, follow the turn with cyclic, reduce collective pitch to the minimum, and allow the aircraft to gradually come to a complete stop. Except in extremely hazardous circumstances, do not attempt to reestablish a hover and do not turn the hydraulics control switch on until the aircraft has come to a complete stop.

9. *Task:* Perform a simulated antitorque malfunction.

Description:

Right and Neutral Pedal Setting. During the last one-third of the downwind leg at cruise power, reduce the throttle to 101 percent N2. The pilot will turn from the downwind leg to the final approach leg, descending to the entry altitude and reducing the airspeed to 60 KIAS. On the final approach leg, the instructor pilot will depress the right pedal until an out-of-trim condition of 10 degrees exists. For neutral pedal setting, the instructor will place the pedals in the neutral position. Maintain the antitorque pedals in this position for the remainder of the maneuver. The pilot will continue to fly the aircraft, maintaining the engine RPM with the throttle at 101 percent N2. When the proper angle is intercepted, decrease the collective to establish and maintain the proper angle of descent. Maintain entry airspeed until approximately 50 to 75 feet AGL. At this point, initiate a slow deceleration so as to arrive over the intended landing point with minimum forward speed for directional control. At approximately 2 feet AGL, retard the throttle, as necessary, to overcome the yaw effect and allow the aircraft to settle. When the aircraft is aligned with the intended landing area, allow it to touch down. After ground contact is established, use the collective and throttle as necessary to maintain lane alignment and minimize forward speed. If the aircraft starts to turn and cannot be controlled with the collective or throttle, position the cyclic, as necessary, to follow the turn until the aircraft comes to a complete stop.

Left Pedal Setting. During the last one-third of the downwind leg, reduce throttle to 101 percent N2. The pilot will turn from the downwind leg to the final approach leg, descending to the

entry altitude and reducing the airspeed to 60 KIAS. On the final approach leg, the instructor pilot will depress the left pedal until an out-of-trim condition of 10 degrees exists. Maintain the pedals in this position for the remainder of the maneuver. The pilot will continue to fly the aircraft, maintaining engine RPM with the throttle at 101 percent N2. When the proper angle is intercepted, decrease the collective to establish and maintain proper angle of descent. Maintain entry airspeed until approximately 50 to 75 feet AGL during the approach. At this point, decrease the rate of descent and forward airspeed so as to arrive approximately 2 feet AGL over the indended touchdown point at effective translational lift. As the aircraft begins to settle, apply collective (maintaining minimum operating RPM) to stop the rate of descent, forward speed, and to align the aircraft with landing area heading. Prior to touchdown, if the aircraft is not aligned with the landing area heading after pitch application, increase the throttle, as necessary, using the torque from the engine to turn the aircraft to the desired heading as touchdown is achieved.

Table 2-2. Items Covered on an NVG Checkride which Appear as Mandatory Flight Evaluation Maneuvers in TC 1-37

1. *Task:* Perform hovering flight.

   Description: Apply cyclic in the desired direction of flight. Maintain heading with pedals, and altitude with collective. Rate of movement should not exceed a brisk walk. To return to a stationary hover, apply opposite cyclic while maintaining altitude with collective and heading with pedals.

2. *Task:* Perform a confined area operation.

   Description: On final approach, perform low reconaissance. When the pilot is able to distinguish small objects on the ground, he will confirm suitability of the selected area for landing; any barriers which constitute a possible hazard; and departure path selected during the high reconnaissance. If the success of the landing is in doubt, a go-around must be initiated before airspeed is reduced below ETL, or descending below the barriers. After landing and prior to takeoff or movement in the landing area, a ground reconnaissance is performed to determine the suitability of the area for ground operations and/or to formulate the takeoff plan. The ground reconnaissance is normally performed from the cockpit. Determine the takeoff plan by evaluating wind, barriers, obstructions, and shape of the cleared area. Select the route to the takeoff point, insuring adequate main and tail rotor clearance while maneuvering. For takeoff over a barrier, it may be necessary to move the aircraft as far downwind as possible. During takeoff, use power, as necessary, to safely clear the barriers while maintaining a constant angle of climb and ground track.

3. *Task:* Perform terrain flight (NOE).

   Description: Refer to FM 1-1 and FM 90-1.

4. *Task:* Perform a hovering autorotation.

   Description: From a stabilized 3-foot hover, retard throttle to engine idle stop, simultaneously applying right pedal to maintain heading and cyclic to maintain position over ground. (While retarding the throttle, do not raise or lower the collective.) As helicopter settles, apply sufficient collective to cushion landing. After ground contact, with the helicopter resting firmly on the ground, smoothly lower collective to full down position. Neutralize pedals and cyclic.

5. *Task:* Perform simulated engine failure.

Description: A practice forced landing will be initiated by the instructor pilot with a throttle reduction. The pilot will immediately lower the collective to maintain rotor RPM in the green while simultaneously applying right pedal as required to properly trim the aircraft. An autorotative turn, if necessary, will be made toward the intended landing area. The approach to the selected area must be planned and executed in such a manner as to cause the final approach to be *generally into the wind*. Check rotor RPM and gas-producer and call out, e.g., "Rotor in the green; gas-producer, 62 percent." The airspeed may be adjusted between minimum descent airspeed and 100 KIAS, as required, in order to reach a suitable touchdown area; however, a minimum of 60 KIAS must have been gained prior to passing through 100 feet altitude AGL. Except for the necessary maneuvering into position, accomplish the autorotative approach and termination similar to a standard autorotation. Adjust the forward speed at termination to permit a safe touchdown compatible with the terrain in the selected area. Upon being given a simulated engine failure, the pilot must assume loss of power and act accordingly. His responsibility is to get the aircraft safely on the ground by establishing a planned autorotative descent to a suitable area and accomplish a smooth touchdown. The decision for making a touchdown rests with the instructor pilot; but, the pilot will plan each forced landing as continuing to the ground. Prior to reaching 200 feet AGL, the instructor will state one of three commands: "POWER RECOVERY," "TERMINATE WITH POWER," or "TOUCHDOWN."

Power Recovery.

- Used under situations when the instructor elects to discontinue as autorotative descent. Recovery is initiated immediately following the instructor pilot's spoken command of "POWER RECOVERY." May be ordered at any time after entering autorotation, but must be given in an altitude that will enable the pilot to return to a normal operating RPM and be recovered prior to passing below 200 feet AGL.

- Upon receiving the command "POWER RECOVERY," the pilot will immediately establish normal operating RPM while simultaneously maintaining proper trim of the aircraft with pedals. When the power has been regained, sufficient collective will be applied to establish a normal climb.

Termination with Power.

- Used during situations when the instructor pilots elects *not* to make an autorotative touchdown, but desires that the pilot continue an autorotative approach to the desired touchdown area

before recovering. This maneuver may be ordered at any time after entering the autorotation, but must be given at an altitude that will enable the pilot to apply full power prior to passing through 100 feet AGL.

- Upon receiving the command "TERMINATE WITH POWER," the pilot will continue the autorotative descent. Prior to reaching 100 feet, he will establish normal engine RPM, trim the aircraft with pedal and remain in autorotation. During the final portion of the approach, sufficient power and collective pitch will be applied to decrease the rate of descent to zero at an altitude of 3 to 5 feet above the ground with the helicopter in a landing attitude. Speed at this point should be the same as if an actual touchdown were to be effected. Proper trim of the aircraft will be maintained throughout the maneuver by use of pedals. An altitude of 3 to 5 feet will be maintained until the aircraft is brought to a stationary hover.

Touchdown. Upon receiving the command "TOUCHDOWN," the pilot will continue the autorotative descent. Prior to reaching 100 feet AGL, airspeed must be a minimum of 60 KIAS. The helicopter must have a normal rate of descent and be in position to terminate in the intended touchdown area. At approximately 50 feet AGL, apply aft cyclic control as necessary to initiate a smooth deceleration (as airspeed decreases, additional rearward cyclic pressure may be required to gain optimum deceleration effectiveness). Insure alignment of the aircraft with the intended touchdown area by proper application of pedals and cyclic. Position collective as required to prevent rotor RPM from increasing above 390 RPM. At approximately 10 to 15 feet skid height, apply sufficient collective to minimize the rate of descent and forward groundspeed. The amount of collective applied and the rate at which it is applied will depend upon the rate of descent. Adjust cyclic, as necessary, to attain a landing attitude. Use collective, as necessary, to cushion the landing. After ground contact is made, continue collective application, as necessary, to complete the landing. Position cyclic and pedals, as necessary, to maintain aircraft heading.

Each operation described in Tables 2-1 and 2-2 was analyzed to ascertain the perceptual and psychomotor skills involved in its performance. Candidate skills were selected which are readily testable by means of psychomotor apparatus tests, and which have consistently appeared in factor studies of apparatus tests.[2] The skills which meet these criteria are listed in Table 2-3, along with the number of critical tasks (out of the possible total of 14) in which each seems involved. The numbers represent the judgments of the two IPs who were interviewed together.

Evaluation of Tests

An evaluation of the various psychomotor apparatus test was then made to find those which reflect performance levels on the most frequently indicated factors from Table 2-3. Tests which have historically been used for pilot selection were considered first. Detailed descriptions of apparatus tests developed in the Air Force Classification Program are provided by Melton.[3] Guilford and Lacey[4] reported results from factor analyses indicating three major psychomotor functions measured by tests included in the Air Force battery, and listed tests which seem to tap those functions. The first function is psychomotor coordination, requiring adjustments of both small and large muscles. This function is measured by the Rotary Pursuit, Complex Coordination, Finger Dexterity, Aiming Stress, and Rudder Control tests. Psychomotor coordination is item 3 of Table 2-3, but the tests described also involve items 5, 7, and 10. Most evidence indicates that manual dexterity should be considered as separate from psychomotor coordination.[5] The second function is psychomotor precision, item 6 on Table 2-3. Tests most consistently loaded on this factor include the Discrimination Reaction Time and Rotary Pursuit. The final function is psychomotor speed, reflected by the speed of marking an answer sheet. However, this function is not involved in apparatus tests.

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[2] E. A. Fleishman. "Testing for Psychomotor Abilities by Means of Apparatus Tests," *Psychological Bulletin*, 1953, 50, 241-262.

[3] A. W. Melton (ed.). *AAF Aviation Psychology Program Research Report, Vol 4*, Washington, D.C.: US Government Printing Office, 1947.

[4] J. P. Guilford and S. I. Lacy. "Printed Classification Tests," *AAF Aviation Psychology Program Research Report, Vol 5*, Washington, D.C.: US Government Printing Office, 1947.

[5] Fleishman, *op. cit.*

Table 2-3. Frequency of Involvement of Basic Psychomotor Factors in Fourteen Important Helicopter Operations

Factor	Description	Frequency
1	Simple Reaction Time (the speed with which an individual can make a predetermined response of a simple type to a stimulus).	14
2	Tapping Ability (the speed with which an individual can oscillate either the fingers or the arm).	0
3	Psychomotor Coordination (integration of muscular movement or coordination between the eye and muscular movements).	14
4	Manual Dexterity (speed of arm-hand coordination).	9
5	Finger Dexterity (the rapid manipulation of objects with the fingers).	0
6	Psychomotor Precision (specified eye-hand coordination).	10
7	Steadiness (coordination emphasizing accuracy while minimizing speed and strength).	12
8	Motor Kinesthesis (operations of the body under conditions of displacement from equilibrium).	4
9	Aiming (paper-and-pencil psychomotor speed with precision).	0
10	Ambidexterity (the ability to use the non-preferred hand).	14

Apparatus tests were used in aircrew selection by the US Army Air Corps during WWII.[6] Tests of steadiness, arm-hand dexterity, and simple speed of reaction administered in early 1942 were gradually replaced by more sophsticated tests, including the Rotary Pursuit, Discrimination Reaction Time, Two-Hand Coordination, and Complex Coordination which were developed by the Army Air Force School of Aviation Medicine (SAM). By April 1952, only four apparatus tests were being used in aircrew selection: SAM Rotary Pursuit, Rudder Control, SAM Complex Coordination, and SAM Discrimination Reaction Time.

Test Selection

Consideration of the skills most frequently used by helicopter pilots, the historical trends in testing to evaluate the level of such skills, and the apparatus tests most readily available and feasible for administration under local conditions led to the selection of three tests for measuring the effect of NVG-induced fatigue on helicopter operations. These tests are the Rotary Pursuit, Two-Hand Coordination, and Discrimination Reaction Time. As simple reaction time is readily testable with the Discrimination Reaction Time Test apparatus, an evaluation of this was planned also.

Validities of the Tests Selected

The validities in predicting graduation-elimination from flight training during WWII and the intercorrelations of the tests are reported by Melton.[7] Data in six tables representing the period from August 1942 through September 1944 were used to compute the average validities and intercorrelations appearing in Table 2-4. This multiple correlation, computed by means of the Doolittle method,[8] is .392. The test of simple reaction time was dropped from the classification battery in August 1942, and is hence not included in the current analysis.

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[6] G. E. Passey and W. A. McLaurin. *Perceptual-Psychomotor Tests in Aircrew Selection: Historical Review and Advanced Concepts*, PRL-TR-66-4, Personnel Research Laboratory, Lackland AFB, Texas, June 1966.

[7] Melton, *op. cit.*

[8] J. P. Guilford. *Fundamental Statistics in Psychology and Education, Third Edition*, New York: McGraw-Hill, 1956.

Table 2-4. Intercorrelations and Validities of Apparatus Tests Selected for NVG Fatigue Evaluation

Variable	1	2	3	Pilot r_{bis}*
1. Rotary Pursuit		.37	.22	.26
2. Two-Hand Coordination			.24	.32
3. Discrimination Reaction Time				.26

*Biserial correlation coefficients between test scores and graduation-elimination in elementary pilot training. The biserial coefficents and intercorrelations were computed from the same data.

Studies conducted more recently confirmed the predictive value for pilot selection of the tests under consideration. Fleishman[9] reported validities of approximately .30 for the Rotary Pursuit Test, and in the range of .30 to .35 for the Two-Hand Coordination Test. Zeidner, Martinek, and Anderson[10,11] evaluated several tests as devices for selecting helicopter pilots, and found biserial *r*s of .30 for the Rotary Pursuit Test and .21 for the Two-Hand Coordination Test with the pass/fail criterion in flight evaluation. Kaplan,[12] considering the same criterion for helicopter pilots, reported biserial *r*s of .27 for the Rotary Pursuit Test, but only .158 for the Two-Hand Coordination Test.

[9] E. A. Fleishman. "Psychomotor Selection Tests: Research and Application in the U.S. Air Force," *Personnel Psychology*, 1956, 9, 449-467.

[10] J. Zeidner, H. Martinek, and A. A. Anderson. *Evaluation of Experimental Predictors for Selecting Army Helicopter Pilot Trainees: I*, Technical Research Note No. 99, US Army Adjutant General's Personnel Branch, 1958.

[11] J. Zeidner, H. Martinek, and A. A. Anderson. *Evaluation of Experimental Predictors for Selecting Army Helicopter Pilot Trainees: II*, Technical Research Note No. 101, US Army Adjutant General's Personnel Branch, 1958.

[12] H. Kaplan. *Prediction of Success in Army Aviation Training*, Technical Research Report No. 1142, US Army Personnel Research Office, June 1965.

Finally, Germain,[13] conducting tests with Spanish aviators, reported validites in keeping with those found elsewhere for the Rotary Pursuit, Two-Hand Coordination, and Discrimination Reaction Time tests.

The foregoing findings provided additional assurance that the skills evaluated by the tests under consideration are directly related to the performance of helicopter pilots. In addition, the tests seem to involve those items most frequently indicated in Table 2-3. Reaction time is measured by both the Simple and Discrimination Reaction Time tests. Psychomotor coordination and precision are involved in both the Rotary Pursuit and Two-Hand Coordination tests. The latter test requires continuous activity with the nonpreferred hand. The only omission of a frequently indicated item is that of steadiness, and a test measuring the type of steadiness required in helicopter operation was not available. The tests that were chosen do appear well suited to reflect performance levels on those tasks most critical in piloting a helicopter.

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[13] J. Germain. "Validity of the U.S. Aircrew Classification Battery in a Sample of Spanish Pilots," in F. A. Geldard and M. C. Lee (eds.), *First International Symposium on Military Psychology*, Publication No. 894, National Academy of Sciences-National Research Council, Washington, D.C., 1961, pp 101-104.

Chapter 3

PERFORMANCE BEFORE AND AFTER FLIGHTS INVOLVING NVG WEAR

Various skill components of critical helicopter tasks were tested before and after flights involving NVG wear. The tests, selected by the methods outlined in the preceding chapter, are described below.

Apparatus Tests

All tests were performed by participants using the naked eye in a room illuminated to approximately 10 foot-lamberts.

Rotary Pursuit Test of Eye-Hand Coordination. The participant in this test attempts to keep a stylus directly over a brightly-lit bar which moves at an irregular velocity around a triangular track. The rate of revolution was set at 30 per minute. Each trial was approximately 20 seconds in duration, with the trial onset and offset controlled by a switch held by the experimenter. The trial duration was timed by a decade counter, manufactured by Cramer Division, Giannini Controls Corporation. Time on target was measured and displayed to the nearest .01 second by an Industrial Timer Corporation timer, which was reset after each trial. The rotary pursuit apparatus was manufactured by Research Media, Inc. Each testing session involved five criterion trials, preceded by two practice trials.

Reaction Time Testing. Since both simple and discrimination reaction time were measured by the same apparatus, this apparatus will be described below before the description of either test.

The reaction time testing apparatus was constructed locally. It consisted of a base, 36" long, 18" wide, and 2" high, upon which was centered a closed box, 12" long, 16" wide, and 12" high. The box housed the circuitry for the apparatus, and provided the vertical panels facing the subject and experimenter. Inside the box were three 24 volt lamps, arranged in a triangle 2" from a hole 3" in diameter in the panel facing the subject. The lights each shined at an intensity of approximately 2 foot-lamberts through frosted acetate covering the hole from the inside. The acetate served to diffuse the light such that the color and not the position of each bulb was apparent. Lights were red, green, or white. The subject's index fingers each rested on a spring-loaded response button; the buttons were centered 5 1/2" from the lateral edges and 6" from the end of the base. Upon the vertical panel facing the experimenter were mounted two indicator lights and a rotary switch. Positioned on the base before the experimenter were five knife switches: one controlling each of the three lights, one for resetting the apparatus, and one for initiating the trial. This latter switch activated

both the light which had been set and the attached 110 volt Lafayette Instrument Company stop clock. The lights were energized by a 24 volt power supply. The base and box atop were painted black.

Simple Reaction Time Test. Latency to respond to the onset of a light by pressing a button was measured for each subject in each condition. Two series of seven trials, two practice trials followed by five criterion trials, were administered in each testing session. The first series required responses to the red light with the index finger of the right hand, and the second involved responding to the green light with the index finger of the left hand.

Discrimination Reaction Time Test. This test is used to measure latency from the onset of a light of a particular color to pressing the correct button in response to that light. This test always immediately followed the Simple Reaction Time Test. Participants pressed the right button in response to the red light, the left button to the green light, and both buttons to the white light. The order of presentations was randomized with the constraint that the same color appeared on no more than two consecutive trials. Before a trial, the experimenter reset the apparatus and stopclock, closed the switch corresponding to the light to be shown on the subsequent trial, and set the rotary switch so that the stopclock was deactivated only when the correct response was made. The trial was initiated by closing the start switch. The stopclock continued to run until the correct response button was pressed. For responses to the white light, the clock was stopped when the second of the two buttons was pressed. Indicator lights signaled the response made to the experimenter, and if an incorrect response was made the trial was scored as a miss. The subject was informed after a miss had occurred, and asked to be cautious. Each testing session consisted of 10 practice trials followed by 33 criterion trials (11 presentations of each color).

Two-Hand Coordination Test. The test is designed to measure the participant's ability to coordinate the movement of both hands to control the movement of a pointer in response to a visually perceived target moving at varying rates along an irregular pathway. Two handles are manipulated to change the position of the pointer. Rotation of the front handle causes the pointer, which is mounted on a microswitch, to move toward the subject with a counterclockwise rotation and away from the subject with a clockwise rotation. Counterclockwise and clockwise rotation of the side handle causes the pointer to move to the left and right, respectively. Rotation of both handles simultaneously causes the pointer to move in directions oblique to the position of the subject. The participant's task is to keep the pointer over the target, a round brass button, as it moves along an irregular clockwise path. When the pointer is on the button, the microswitch is closed and current flows to a stopclock attached to the apparatus. An exact copy of the SAM apparatus was used, which contains internal programs for four different patterns of movement of the target around the clockwise path. Each testing sesssion therefore consisted of four trials, with no practice permitted. The duration of each trial was approximately one minute.

Design of the Experiment

Procedure

Subjects were obtained from the 6th ACCB at Fort Hood, Texas. All were aviators of rotary wing aircraft. The study was conducted using facilities furnished by the 6th ACCB in order to allow the shortest possible subject transportation time betweeen deplaning and testing. The study was run from 27 June to 7 July 1978.

A group of 10 aviators was given each apparatus test under two conditions. In one condition each member was tested to establish a baseline standard for unfatigued performance before a flight. The other condition involved testing each subject just after he had completed a flight involving NVG use. This second condition was used to determine the extent of decrements in the skills under analysis resulting from fatigue induced by NVG wear. All NVG flights occurred in the daytime, and were made possible by attaching filters, each weighing approximately 1.5 ounces, to the front of each NVG lens. To prevent confounding of learning and fatigue effects, half the aviators received the battery of tests for the first time in the Postflight (fatigued) condition, while the other half initially received the battery in the Preflight (baseline) condition.

No more than three subjects were in the experiment room performing the various tests at any given time. Each subject was first briefed about the nature of the tests, and asked to give his very best performance. Care was taken to avoid referring to aviators in the Postflight condition as "fatigued," since such references might introduce lowered performance expectations. Participants were assured that the results of the tests would not become part of their personnel records.

Testing was preceded by the distribution of a brief personal history form (see Appendix A). Following the completion of this form, the tests were administered to the subject. The sequence of the tests was varied randomly within each control order, with both reaction time tests considered as an inseparable unit. No subject received the tests in the same order for both conditions.

Before each test, instructions were read to the participant, and questions were answered as appropriate. A full set of instructions for each test appears in Appendix B, along with the data collection form which was marked by the experimenter. The test battery took approximately 30 minutes to complete. After all tests were completed, the subject was thanked for his participation and excused.

Results

Description of the Sample

The 10 participants were all male aviators from the 6th ACCB, Fort Hood, Texas. One man was a captain, two were first lieutenants, and the rest were warrant officers (4 CW2s and 3 WO1s). Other personal statistics appear in Table 3-1. The range of durations of NVG wear for the flight preceding the Postflight condition was .75 to 1.5 hours. No difference on any index between orders approached statistical significance (all *ps* >.10).

Table 3-1. Personal Statistics Reported by the Sample

Index	Order (Preflight then Postflight) Mean (n = 5)	Order (Postflight then Preflight) Mean (n = 5)
Age	26.4	26.6
Years of Military Service	5.2	4.8
Career Total Hours of Flight Time	1110	1532
Career Total Hours of NVG Use	5.57	7.20
Hours of NVG Wear Prior to Postflight Tests	1.20	1.38

Test Results

Order was always analyzed as a between-subjects variable. Conditions and all other variables constituted the within-subjects variables.

Rotary Pursuit Test of Eye-Hand Coordination. Trial durations were timed manually by the experimenter rather than by automatic means. Mean trial duration for Preflight and Postflight conditions, as well as the difference in durations for these conditions between the two orders, was compared by analysis of variance. No difference was statistically significant. Overall mean trial duration was 20.013 sec., and standard deviation was .084 sec.

Percent of time on target for each trial was computed for each subject in each condition. These trial means are reported separately for each order in Table 3-2. Analysis of variance was conducted on the data, and these results are shown in Table 3-3. The significant Order by Trials interaction is plotted in Figure 3-1. For Order 1, the slight

Table 3-2. Mean Time on Target for Each Trial on Each Condition within Each Order on the Rotary Pursuit Test

Condition		Trial 1	2	3	4	5
Order 1 (Preflight then Post-flight)	Preflight	70.223	71.024	70.112	72.949	74.291
	Postflight	60.373	61.383	53.877	52.952	49.365
Order 2 (Postflight then Pre-flight)	Preflight	58.010	63.575	62.418	63.550	71.600
	Postflight	50.666	55.117	60.719	59.516	70.224
Mean per Trial		59.818	62.775	61.782	62.241	66.370

Table 3-3. Analysis of Variables in the Rotary Pursuit Test

Source	SS	df	MS	F	p
Total	30,988.246	99	--	--	--
Between Subjects	12,966.984	9	--	--	--
Orders	111.641	1	111.641	.069	n.s.
$Error_O$	12,855.343	8	1606.918	--	--
Within Subjects	18,021.262	90	--	--	--
Conditions	2,682.152	1	2682.152	1.212	n.s.
Trials	455.306	4	113.827	2.900	<.05
OxC	834.407	1	834.407	.723	n.s.
OxT	1,148.309	4	287.077	7.301	<.01
CxT	86.298	4	21.575	.370	n.s.
OxCxT	454.459	4	113.615	1.95	n.s.
$Error_C$	9,237.607	8	1154.701	--	--
$Error_T$	1,258.281	32	39.321	--	--
$Error_{CxT}$	1,864.443	32	58.264	--	--

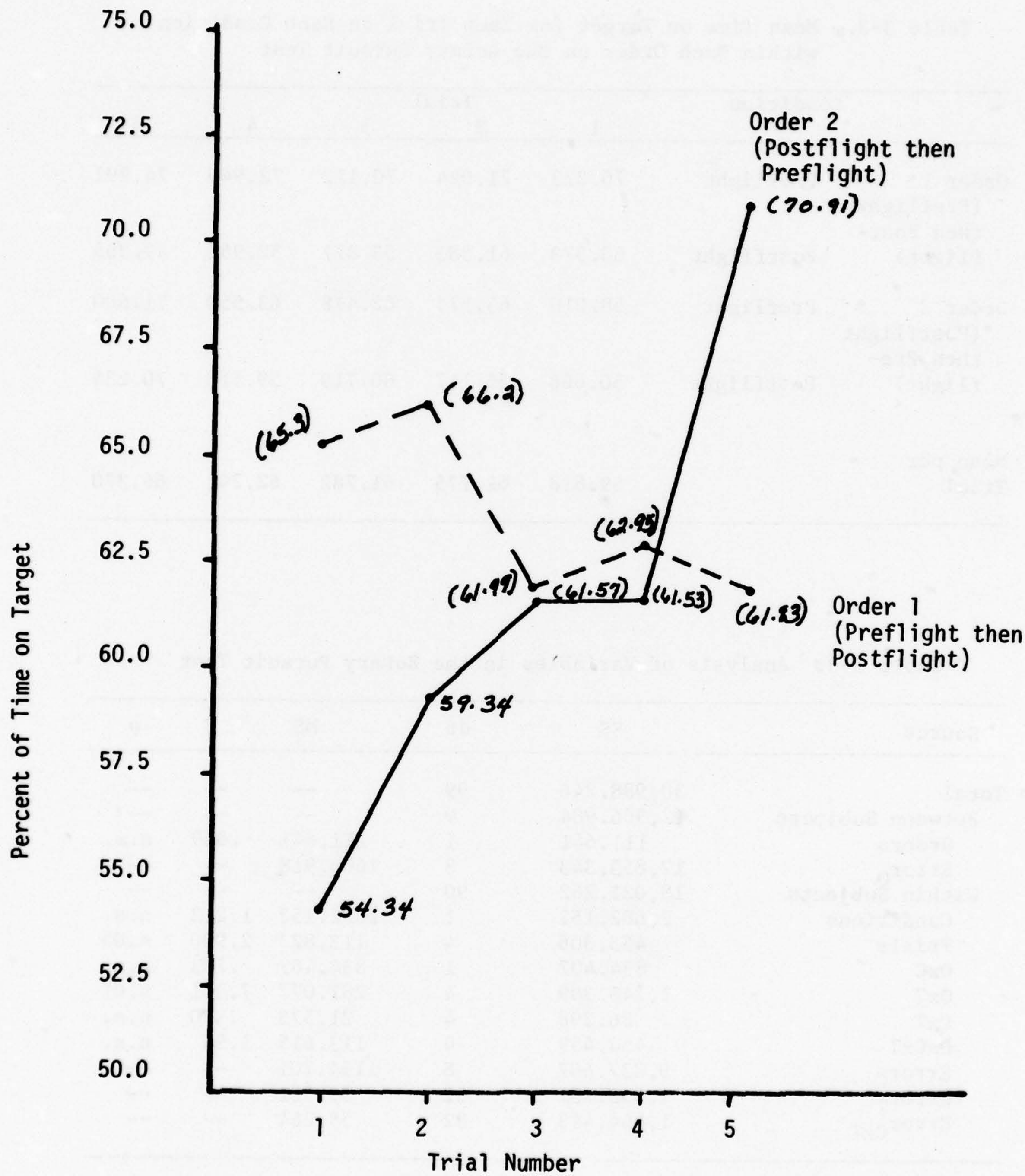

Figure 3-1. Rotary pursuit: Order by trials interaction.

decrease in performance over trials resulted from a combination of consistent performance over trials in the Preflight condition (ironically indicating little learning effect) and a decrease in performance over trials in the Postflight condition (perhaps due to buildup of fatigue as the test was performed). For Order 2, subjects showed an increase in performance over trials in the initial Postflight condition (probably due to learning), coupled with an increase in performance over trials during later testing in the Preflight condition. Mean performance differed significantly between trials, seemingly due to the predominance of a learning effect (see bottom of Table 3-2).

The difference in performance between the Preflight and Postflight conditions, the means and standard deviations for which appear in Table 3-4, was not statistically significant. However, the difference of 10.357 percent was slightly larger in magnitude than the statistically significant difference found in an earlier study on the same test conducted under the same conditions using a much larger sample.[1] This earlier comparison used median rather than mean performance scores, since one anomalous trial has a large effect on the mean but leaves the median undisturbed. However, the difference between the average median percent time on target in the current study for the Preflight and Postflight conditions (67.677 and 56.610 percent, respectively) only approached statistical significance ($t = 1.63$, $df = 9$, $.05 < p < .10$, one tailed).

Table 3-4. Means and Standard Deviations for Preflight and Postflight Conditions on the Rotary Pursuit Test

	Mean	SD
Preflight	67.776	14.603
Postflight	57.419	19.078

<u>Simple Reaction Time Test</u>. Latency to respond was recorded for each trial, and results were analyzed by analyis of variance. For reaction time data, it is customary to use median times rather than means since one particularly long latency has a large effect on the mean but not on the median. Mean and median reaction times for each subject were compared for each color within each condition, and none of the

[1] G. D. Chastain, W. H. Ton, and A. L. Kubala. *Fatigue Effects From Wearing the AN/PVS-5 Night Vision Goggles*, ARI Technical Report, Human Resources Research Organization, Alexandria, Virginia, in process.

differences approached significance (all *ps* > .10). Hence, median times were considered as the response measure.

The results of the statistical analysis appear in Table 3-5. Since neither the effect of order nor any interaction with this variable was statistically significant, Table 3-6 partitions the data only by Color and Conditions.

Table 3-5. Analysis of Variables in the Simple Reaction Time Test

Source	SS	df	MS	F	p
Total	1879.5	39	--	--	--
Between Subjects	1177.0	9	--	--	--
Orders	14.4	1	14.4	.099	n.s.
$Error_O$	1162.6	8	145.325	--	--
Within Subjects	702.5	30	--	--	--
Conditions	144.4	1	144.4	6.959	<.05
Colors	84.1	1	84.1	18.689	<.05
OxCon.	96.1	1	96.1	4.631	n.s.
OxCol.	6.4	1	6.4	1.422	n.s.
CxC	90.0	1	90.1	9.068	<.025
OxCxC	.1	1	.1	.01	n.s.
$Error_{Con.}$	166.0	8	20.75	--	--
$Error_{Col.}$	36.0	8	4.5	--	--
$Error_{CxC}$	79.4	8	9.925	--	--

Table 3-6. Mean Latencies for Each Color Within Each Condition on the Simple Reaction Time Test

	Color		
Condition	Red	Green	Mean
Preflight	248.0	249.0	248.5
Postflight	316.0	257.0	286.5
Mean	282.0	253.0	

The significant interaction of Color with Condition indicates that longer response times occurred in the Postflight condition, with reaction to the red light contributing most to the increase. Hence, overall, responses to red were significantly slower than to green, and Postflight responses were significantly slower than Preflight. This

finding is at first somewhat puzzling. However, responses to red were always made with the right hand, and perhaps some aspect of flight operations proved more fatiguing to the right hand than to the left. Interviews with IPs provided support for this explanation. All helicopter operations besides those very occasional ones involving the collective are performed with the right hand. Therefore, the effect observed seems to be of physiomotor origin rather than one reflecting differences in latency to react to red and green. If physiomotor factors were responsible for the differences observed, results of the Discrimination Reaction Time Test which always immediately followed the Simple Reaction Time Test might reflect this fatigue by again showing slower reactions for the right hand in the Postflight condition.

Discrimination Reaction Time Test. Latency to respond was recorded for each trial on which the correct response was made. Number of misses (incorrect responses) to each color was also noted, although latencies were not recorded for these responses. Using the same rationale that was used for the Simple Reaction Time Test, medians were considered as the response measure rather than means, although there was no significant difference between the measures ($p > .10$).

The results of the statistical analysis appear in Table 3-7. The only significant difference was between latencies to respond to the three colors.

Table 3-7. Analysis of Variables in the Discrimination Reaction Time Test

Source	SS	df	MS	F	p
Total	2539.433	59	--	--	--
Between Subjects	770.443	9	--	--	--
Orders	117.600	1	117.600	1.441	n.s.
Error_O	652.833	8	81.604	--	--
Within Subjects	1769.000	50	--	--	--
Conditions	26.666	1	26.666	.859	n.s.
Colors	826.433	2	413.207	16.773	<.001
OxCon.	.067	1	.067	.002	n.s.
OxCol.	16.900	2	8.45	.343	n.s
CxC	46.242	2	23.122	1.849	n.s.
OxCxC	10.024	2	5.012	.401	n.s.
$\text{Error}_{Con.}$	248.433	8	31.054	--	--
$\text{Error}_{Col.}$	394.167	16	24.635	--	--
Error_{CxC}	200.067	16	12.504	--	--

The latencies, broken down by condition, are given in Table 3-8. Although the effect of Conditions was not statistically significant, the average median response time differences were in the expected direction for two of the three colors. Overall, response to the red light was fastest, and speed of response to the other colors was about equal. This result provides no support for the explanation of results of the Simple Reaction Time Test that responses made with the right hand were significantly slower for the Postflight condition because the right hand becomes more fatigued during flight. IPs who were interviewed regarding these results were of the opinion that the right hand is indeed more fatigued. However, aviators are conditioned to make rapid responses to the onset of a red warning light, whereas, no such conditioning occurs to green or white lights. Thus, the conditioning to respond rapidly to a red light may have overriden the fact that such responses were necessarily made with the more fatigued right hand. This might be expected to occur when some speeded response decision is necessary, and not in the simple case in which a predetermined response is required (as in the Simple Reaction Time Test).

Table 3-8. Latencies in Msec to Response by Condition and Color in the Discrimination Reaction Time Test

		Color		
Condition	Red	Green	White	Mean
Preflight	414.5	498.5	521.0	47.80
Postflight	451.5	506.5	516.0	49.13
Mean	433.0	502.5	518.5	

The distribution of errors among the various sources is shown in Table 3-9. Note that an error to the white light was not possible since both buttons were pressed in the correct response. Parametric analyses

Table 3-9. Percent of Responses in Error in the Discrimination Reaction Time Test

		Condition	
Order	Color	Preflight	Postflight
1 (Preflight then Postflight)	Red	23.818	7.273
	Green	10.090	24.455
2 (Postflight then Preflight)	Red	7.273	14.545
	Green	18.182	10.090
	Mean	14.545	14.545

were precluded by the positive skew in the distribution of errors, as 40% of the testing sessions showed no errors to a particular color. Moreover, as the main variable of interest (Conditions) showed the same error rate at each of the two levels, no analysis was attempted on the error data.

Two-Hand Coordination Test. Percent of time on target was computed for each trial. For each testing session of four trials, median time on target was calculated as the mean of the second highest and second lowest times. No statistically significant difference existed between this figure and the mean time of all four trials for subject in any order or condition (all *p*s > .10). However, since some subjects were observed to have substantial variance in performance over trials, the median figures were used as the response measure.

Results of the analysis of variance conducted on the data appear in Table 3-10. The only statistically significant effect, the Order by Conditions interaction, probably reflects the learning which occurred over trials. That is, the average median for the second testing session tended to be higher than that for the first, regardless of Condition. The average medians are shown in Table 3-11.

Table 3-10. Analysis of Variables in the Two-Hand Coordination Test

Source	SS	df	MS	F	p
Total	2677.946	19	--	--	--
Between Subjects	1553.737	9	--	--	--
Orders	58.426	1	58.425	.313	n.s.
$Error_B$	1495.311	8	186.914	--	--
Within Subjects	1124.209	10	--	--	--
Conditions	4.049	1	5.049	.119	n.s.
OxC	778.681	1	778.681	18.296	<.01
$Error_w$	340.478	8	42.560	--	--

Discussion

The difference between Preflight and Postflight performance for the Simple Reaction Time Test was significant, and mean differences for the Discrimination Reaction Time Test were in the predicted direction. The Rotary Pursuit Test showed marginally significant differences in performance between the Preflight and Postflight conditions. Learning effects seemed to interfere with a clearer manifestation of differences on this latter test, and especially on the Two-Hand Coordination Test. Subjects might be given initial practice sessions before testing in future examinations so that the learning effect would not be a factor in the criterion measures.

Table 3-11. Average Median Percent of Time on Target for Each Variable on the Two-Hand Coordination Test

Order	Condition: Preflight	Condition: Postflight
1 (Preflight then Postflight)	50.990	64.596
2 (Postflight then Preflight)	66.911	55.581
Mean	58.905	60.089

Thus, confirmation of the hypothesis that fatigue from NVG wear would be reflected in performance decrements on skills necessary to helicopter operation is not overly strong. One major reason for this result might be that fatigue did not sufficiently develop due to the brevity of the NVG flights before Postflight testing. Estimates have been reported that discomfort does not set in until after almost 45 minutes of NVG wear, and that wear can continue for over 90 minutes before performance degradation occurs.[2] In the current study, no aviator tested in the Postflight condition had worn the NVG for over 90 minutes in the immediately preceding flight, with an overall average of only around 77 minutes of wear. Original requests were for aviators to wear the NVG for around 120 minutes before Postflight testing, but restrictions on the use of flight training areas coupled with the large number of aviators requiring NVG training made this goal unattainable. Likewise, testing a larger sample would have been desirable, but was prevented as many aviators were flying simultaneously and thus only a few could be tested immediately postflight.

Considering the relatively short durations of NVG wear and the small sample involved, the results of the apparatus tests indicate a strong likelihood that extended NVG flights would result in the degradation of skills necessary in flying. All of the critical tasks surveyed involved eye-hand coordination and reaction to visual cues. Since these factors showed some adverse effects after even brief NVG flights, fatigue effects from longer flights might be expected to be apparent in general flight performance.

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[2] *Ibid.*

Chapter 4

SUMMARY AND CONCLUSIONS

The purpose of this investigation was to determine the effects of fatigue from wearing the NVG on various skills involved in helicopter operations, and to identify those maneuvers most likely to be adversely affected from NVG wear. It was found that eye-hand coordination and reaction time tend to suffer after from 45 minutes to 1.5 hours of NVG wear and that these factors are involved in all of the most crucial and frequently performed piloting operations.

Because of restrictions on the number of aviators tested as well as the length of time the NVG were worn by examinees, the differences between preflight and postflight performance were not statistically strong. A replication with a larger sample and longer NVG wearing time is therefore needed. Postflight comparison of the performance of subjects who had and had not worn the NVG during the flight should be made. Significant differences found on this comparison would indicate a definite need to develop ways of reducing discomfort and fatigue from the NVG.

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APPENDIX A

PERSONAL HISTORY AND SUBJECTS' OVERVIEW

Subject No. __________ Condition __________

AN/PVS-5 Visual Performance Battery

Name ____ Date __________
(Last) (First) (MI)

Rank ______________ Military Unit ______________________________ MOS ______

Age _____ Years Service ______

Career Total Hours Flight Time ________

1. Approximately how long did you wear the AN/PVS-5 goggles immediately prior to arriving here today?

2. Approximately how many total hours have you worn the AN/PVS-5 goggles?

_____

Subject No. _________ Condition _______________

Name ______________________________ Date _________ Time ________am/pm

AN/PVS-5 Performance Battery - Instructions for Participants

I. Today you will be performing a series of visual tasks that should require about one hour to complete. The purpose of these tasks is to provide information regarding soldiers' ability to perform various visually guided functions under specific conditions. Your patterns of performance will help the Army to make decisions on equipment which will benefit all users. Your best effort is, therefore, essential. However, information concerning your performance will not become part of your record and will not be used in whole or in part in making any determination about you personally.

II. Proceed to the following stations in this order:

1st _____

2nd _____

3rd _____

APPENDIX B

INSTRUCTIONS AND DATA COLLECTION FORMS FOR AN/PVS-5 PERFORMANCE TEST BATTERY

Instructions for Reaction Time

This is a test of how fast you can react to a signal. The signal will be a red, a green, or a white light, and your task will be to respond with these buttons as quickly as you can after a light comes on. Push the right button for the red light, the left button for the green light, and both buttons for the white light. Use the index fingers of each hand, keeping your fingers on the buttons at all times.

I will be sitting back here recording how long it takes you to make each response. If you push the wrong button, or if you push both buttons when only one button is correct, some indicator lights will tell me that you have made the wrong response. Respond as quickly as you can, but make your responses as accurately as possible. Only the first response you make to a light will count, and if you make an error that trial will be scored as a miss. The order in which the lights appear is randomized.

Before each trial I will say the word "ready" about two seconds before a light comes on. When you push a button you need not hold it down, merely press it all the way and release it. First you will practice with each hand. We will start with the right hand and the red light. Only the red light will come on and you will push only the right button. We will have two practice trials, and the five trials for time.

Now we will do the same thing with the left hand and the green light. You will get two practice trials and then five trials for time.

Now we will go to the more complex situation where you will push the right button for the red light, the left button for the green light, and both buttons for the white light.

We will begin with 10 practice trials, followed by 33 criterion trials. Are there any questions?

Subject No. ____ Condition ____

DISCRIMINATION REACTION TIME

Name ______________________ Date ____ Time ____ am/pm

	Trial No.	Cond.	RT	Trial No.	Cond.	RT	Trial No.	Cond.	RT
Practice	1	B	____	11	R	____	31	G	____
	2	G	____	12	B	____	32	B	____
	3	B	____	13	G	____	33	B	____
	4	G	____	14	R	____	34	G	____
	5	R	____	15	G	____	35	R	____
	6	R	____	16	G	____	36	R	____
	7	B	____	17	R	____	37	G	____
	8	B	____	18	G	____	38	R	____
	9	G	____	19	B	____	39	G	____
	10	B	____	20	B	____	40	G	____
Cri-terion	1	R	____	21	R	____	41	B	____
	2	G	____	22	R	____	42	R	____
	3	R	____	23	G	____	43	G	____
	4	B	____	24	R	____	44	B	____
	5	G	____	25	G	____	45	R	____
	6	R	____	26	B	____	46	B	____
	7	B	____	27	R	____	47	R	____
	8	G	____	28	B	____	48	B	____
	9	R	____	29	R	____	49	B	____
	10	B	____	30	G	____	50	G	____

Errors: R ____	Mdn RT: R ____	Mean R ____	SD ____
G ____	G ____	G ____	SD ____
B ____	B ____	B ____	SD ____
Total ____	Overall ____	Overall ____	SD ____

Subject No. _____ Condition _____

SIMPLE REACTION TIME

Name ____________________________________ Date _____ Time _____am/pm

RED		GREEN	
	__________		__________
	__________		__________
1	__________	1	__________
2	__________	2	__________
3	__________	3	__________
4	__________	4	__________
5	__________	5	__________

Mean	_____	Mean	_____
Mdn	_____	Mdn	_____
SD	_____	SD	_____

<u>Overall</u>

Mean _____

Mdn _____

SD _____

Instructions for Two-Hand Coordination

This is a two-hand coordination task. The black disc will rotate very slowly in a clockwise direction. This brass button will move with the disc in an irregular manner within the curved slot. Your task will be to keep the microswitch on top of the button. Your score is the total amount of time that you stay on target for each trial. When you get off target get back on as quickly as possible. Each trial will last about a minute, and there will be four trials.

You move the microswitch by turning these two handles at the same time. The front handle moves the button toward and away from you (demonstrate) and the side handle moves it from side to side (demonstrate). Now you grab the handles and moves the button yourself, first with the front (pause), then with the side (pause).

Before each trial, put the microswitch on target. I will say "ready" and I want you to put your hands to your sides. Two seconds later I will start the machine, and you grab the handles and try to stay on target. Never let go of the handles to spin them. There will be no practice. Are there any questions?

Subject No. _____ Condition _____

TWO HAND COORDINATION

Name ______________________ Date _________ Time ______am/pm

Trial No.	Time on Target	Percent
1	______________	________
2	______________	________
3	______________	________
4	______________	________
Mean	______________	________
Mdn	______________	________
SD	______________	________

Instructions for Pursuit Rotor

The object in this task is to keep this black stylus directly over the rotating light. You will notice that the speed at which the light seems to move around the triangular track is not constant--it speeds up while going around the corners of the triangle.

First, I want you to put the stylus in the center of the triangle like this. When the light comes on, immediately move the stylus to a position over the light, then move the stylus around the track like this, always trying to keep the stylus directly over the light. Keep the tip of the stylus pressed against the glass at all times. Twenty seconds after the light comes on it will go off, and at that time I want you to immediately move the stylus back to the center of the triangle like this so you will be ready for the next run.

Do you have any questions?

Now, I'm going to give you a couple of practice runs, after which you will have five performance runs. I will be keeping track of the time out of twenty seconds that you were able to stay on target for each run.

Let's try the first practice run now.

Subject No. _____ Condition __________

PURSUIT ROTOR

Name ___________________________________ Date ___________ Time ______am/pm

	Time on Target (sec)	Out of (sec)	%
Practice:			
Trial No.			
1	_____	_____	_____
2	_____	_____	_____
Criterion:			
Trial No.			
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
Mean		_____	_____
SD		_____	_____
Median			_____

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